TRAWL SHRIMP INDEX FISHING IN THE SOUTHERN DISTRICT OF THE COOK INLET MANAGEMENT AREA SPRING 1992 and 1993

by

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INTRODUCTION

The commercial trawl shrimp fishery in the Cook Inlet Management Area (H) began with intermittent harvests in the 1950's and early 1960's, but the small catches did not accurately reflect the size of the stocks in the area. In the late 1960's trawl catches reached the five million pound mark annually and remained near that level through the early 1980's (Table 1,). More recently, the commercial fishery has been closed since the fall of 1986 due to low abundance levels. Pink shrimp (*Pandalus borealis*) historically made up the bulk of the commercial harvest, with sidestripes (*Pandalopsis dispar* seasonally making up a lower but still significant portion of the catch. Humpy shrimp (*Pandalus goniurus*) at times comprised up to 50 percent of the annual commercial harvest, but this species appears to undergo the most erratic population fluctuations and their contribution to the most recent fisheries were minor. Coonstripes (*P. hypsinotus*) consistently made up approximately five percent or less of the harvest. Effort has varied from a low of one vessel during 1968 to a high of 23 in 1981.

Trawl shrimp population abundance index surveys have been conducted by the department in the Southern District once each year (May) from 1971 through 1975, twice annually from 1975 through 1990 (May and October) and once annually from 1991 to 1993. Results of the surveys have been used to monitor stock status and establish harvest guidelines for each of the three regulatory sub-seasons (summer, fall, and winter) during the fishing year.

As the shrimp populations declined the major distribution of shrimp retreated from all of Kachemak Bay to concentrations east of Homer Spit only. Because shrimp were not present in the large area west of Homer Spit after the decline, the percent error of the

population estimate increased with the movement of shrimp to east of Homer Spit. By reducing the percent error the confidence in the population estimate increases. The goal of this paper is to test weather or not stratification of the historic data using all the stations fished will reduce the percent error of the population estimate, and incorporate the resultant stratified and unstratified estimates into the results from the 1992 and 1993 surveys. Formulas and explanation for the calculations of the unstratified and stratified abundance estimate for pandalid shrimp and fish and non-shrimp are found in Appendices A and B.

METHODS

History

The survey was designed by dividing Kachemak Bay into a one square nautical mile grid. Area-swept population estimates were made by first randomly selecting stations in depths greater than 20 fm (36.6m). In each selected station a single one nautical mile tow was made using a 66 foot Nordby net from 1971 to 1974 and a 61 foot high opening shrimp net designed National Marine Fisheries Service (NMFS), 1975 to present. The net was changed because in comparative tows, the 66-foot Nordby trawl net was 50 percent as efficient as NMFS net (Davis, 1982). The shrimp catch from the tows were weighed and used to calculate the mean shrimp per nautical mile. The mean was multiplied by a factor converting the effective fishing width of the net to pounds of shrimp per square nautical mile. The resultant product then was multiplied by the area of shrimp habitat yielding a population estimate in pounds of shrimp.

Since the survey began the area surveyed has remained the same; the only major change was the method of station selection. In order to

reduce net damage the stations were kept the same after the spring 1984 survey, thereby changing the survey design from random to systematic station selection. In 1988 additional stations east of the Homer Spit were added to allay the fishermen's fears that the survey was not adequately sampling shrimp population concentrations. These additions increased the total area sampled by 2 square nautical miles and allowed tows to be made closer to the power line crossing Kachemak Bay. Although additional stations were fished from the fall of 1988 to the present only the traditional stations were used to calculate the population estimate (Hammarstrom, 1991).

Stratification and Survey Design 1992 and 1993

Kachemak Bay was stratified into four strata: far west, near west, east open and east closed (Figure 1). The stratification was based on habitat type, geographic location, shrimp sex and size. The far west geographic stratum in recent years had few shrimp present. The near west stratum catch was composed of predominately large female shrimp whose density was relatively sparse. The catch from the east open stratum was composed of both sexes of animals exhibiting historically moderate densities. The east closed area was closed to commercial trawl shrimp fishing because it was a shrimp nursery and predominantly males.

One nautical mile tows were made in systematically selected one square mile stations in the east closed, east open and near west strata. To reduce the potential of net damage and complete the survey in a timely manner, one-half mile tows were made in stations in the far west stratum. In more recent years there have been very few shrimp caught in the far west stratum.

In addition to stratification of the population estimate, a search was conducted of the skipper's logs from fall 1986 to 1991 to see if towing any stations consistently caused major net damage. As a

result stations K-15, J-15 and O-20 of the near west stratum and east open stratum were not towed. To reduce survey time, far west stratum stations H-5, H-6, J-7 and I-9 with zero or trace shrimp catch were not towed.

Tows were made in Tutka Bay and Sadie Cove. However these tows were not used in the population estimate. Prior to 1981 Tutka/Sadie was not sampled. Historically the catch from these areas was treated separately and were never used for the population estimate.

Catch Sampling methods

Upon completion of each tow, the total catch was weighed and all very large non-shrimp objects (rocks, stumps, pots, large fish, etc.) were removed from the catch, weighed directly, and discarded. Additionally, all Pacific halibut (*Hippoglossus stenolepis*), large Pacific cod (*Gadus macrocephalus*) and rock fish (genera *Sebastes* and *Sebastolobus*) were sorted out of the catch prior to sampling. These four genera were then counted and weighed.

Subsampling the remaining catch was based on the appearance of species composition.

Tows greater than 50 percent shrimp

Two random samples of approximately 10,000 grams each (3 gallon bucket) were collected if the catch was greater than five hundred pounds. For catches of less than five hundred pounds, one 10,000 gram bucket sample was collected. Each 10,000 gram bucket sample was then separated by fish, other non-shrimp material (which included finfish, flatfish, shellfish other than shrimp, and any miscellaneous debris), and shrimp. Each of these groups was weighed to obtain percentages of the total catch.

From the remaining shrimp in either the one or two bucket sample, a 2,500 gram subsample was randomly selected (one 2,500 gram sample per bucket). The shrimp were further separated by species. Each species was weighed separately for species composition. In addition, small quantities of shrimp from the subsample were labelled and retained for later length frequency analysis in the laboratory. In the case of pink shrimp, which generally comprise the highest percentage of each shrimp subsample, a quantity of approximately 350 to 400 grams was retained from each station. For the other shrimp species, all individuals were normally retained because the subsample usually amounted to a relatively small number of shrimp per station.

Tows greater than 50 percent fish

One or two basket samples of approximately 15,000 to 25,000 grams each were collected randomly from the catch. If the catch weighed 500 pounds or more two basket samples were taken. For catches weighing less the 500 pounds one basket sample was taken. Shrimp, fish and other invertebrates animals (non-shrimp material) were subsequently separated by species, counted, and weighed.

Small tows with total catch weighing 75 to 150 pounds.

The whole catch was separated by shrimp and fish species, counted and weighed.

Although other species of shrimp were caught only the pandalid species are of commercial value. The term "pandalid shrimp" as used in this report only refers to the those harvested in the commercial fishery (pink, sidestripes, coonstripe, and humpy). Spot shrimp (*Pandalus platyceros*) were occasionally caught however they were far less than 0.01 percent of the pandalid shrimp catch.

The term "other shrimp" refers to non-commercial shrimp such as *Lebbeid* sp., *Crangon* sp., *Sclerocrangon* sp. and *Eualus* sp.

RESULTS

Stratification of Historic Data

The goal of the stratification of the population estimates was to reduce the percent error and incorporate all stations fished in the population estimate. Stratification reduced the percent error in the shrimp estimates in 81 percent of the surveys by an average of 10 percent (Table 2). Stratification was most beneficial for the 1984 through 1989 spring and fall surveys, where the difference between the stratified and unstratified percent error ranged between 12 and 29 percent. Also, stratification resulted in smaller population estimates.

On the other hand stratification of the fish population estimates was not nearly as advantageous (Table 3). The stratified percent error was less than the unstratified estimate in only 7 of the 15 spring surveys and 2 of the 14 fall surveys. This may be in part due to the combining of all fish and non-shrimp species together. Prior to the fall 1988 survey, fish, non shrimp invertebrates and debris were not separated by species. As a result no attempt was made to estimate fish populations by individual species. Stratification did not necessarily produce a lower fish and non-shrimp population estimate.

Spring 1992 Survey

The spring 1992 trawl index survey was conducted aboard the state research vessel PANDALUS during the period May 19 through May 28.

A total of 38 tows were completed including two tows in Tutka Bay and Sadie Cove. The mean catch was 72.9 pounds per tow of pandalid shrimp for the 36 stations used in the population estimate. The midpoint of the unstratified systematic estimate was 1.25 million pounds of pandalid shrimp with a percent error of 22.2 (Table 2). Stratification of the data resulted in a midpoint estimate of 900,000 pounds of pandalid shrimp, with a percent error of 20.7. The difference between the stratified and unstratified error was 1.5 percent. Catches from Tutka Bay and Sadie Cove stations have not been used for past population estimates, and were not used in either the unstratified or stratified population estimates.

The east open stratum had the highest mean catch of 114.6 pounds of pandalid shrimp per tow followed by the east closed with 105.6 pound of pandalid shrimp per tow. The near west stratum had a mean of 73.4 pounds of pandalid shrimp. The far west stratum had a mean of 16.5 pounds of pandalid shrimp (Table 4).

The pandalid shrimp catch by station for the spring 1992 survey is shown on Table 5 and Figure 2. The east open stratum had the survey's largest single station pandalid shrimp catch of 309 pounds in station O-22. The third largest catch of 197 pounds was taken from N-22. A near west stratum station K-16 had the second largest pandalid shrimp catch of 216 pounds. The catches in Tutka Bay and Sadie Cove were 266 and 23 pounds respectively.

Pandalid shrimp species composition was predominantly pink shrimp, which were 100 percent of the far west stratum shrimp catch (Table 5). The near west pandalid shrimp catches were 93.6 percent pink shrimp and 6.4 percent sidestripe shrimp. The east open pandalid shrimp catch was 97.2 percent pink shrimp, 2.4 percent sidestripe shrimp, 0.3 percent coonstripe shrimp and 0.2 percent humpy shrimp. The east closed pandalid shrimp catch was 97.9 percent pink, 1.1 percent coonstripe, 0.5 percent sidestripe and 0.5 percent humpy.

Tutka and Sadie shrimp catches were 90.4 percent pink, 6.6 percent coons, 1.5 percent humpy and 1.5 percent sidestripe.

The counts per pound (CPP) of the pink shrimp from field measurements by stratum for the spring 1992 survey were: 143.9 (east open stratum), 154.5 (east closed) and 158.6 (near and far west combined) (Table 6).

The mean spring 1992 fish and non-shrimp catch for all stations, with the exception of Tutka Bay and Sadie Cove, was 598.8 pounds (Table 3). The unstratified fish and non-shrimp population estimate was 10.23 million pounds with a percent error of 13.4. Stratification of the data yielded a fish and non-shrimp population estimate of 8.62 million pounds with a percent error of 10.8.

Figure 3 illustrates the fish and non-shrimp catch in pounds by station for the spring 1992 survey. A population estimate for each fish or non-shrimp species was not calculated. However the most abundant species by weight was walleye pollock (*Theragra chalcogramma*) followed by flathead sole (*Hippoglossoides elassodon*). There were seven stations whose fish and non-shrimp catches exceeded one thousand pounds, the largest catch was 1,547 pounds in station O-23 followed by 1,502 pounds in U-27. A more detailed fish and invertebrate species composition by stratum is contained in Appendices C through G. The largest Tanner crab (*Chionoecetes bairdi*) catch was an estimated 420 pounds taken from station K-16.

Spring 1993 Survey

The Spring 1993 trawl index survey was conducted aboard the PANDALUS from May 17 through May 26. The mean pandalid shrimp catch was 10.4 pounds per station for the 35 stations towed. The unstratified population estimate was 181,000 pounds of pandalid shrimp with a percent error of 26.9. Stratification of the data

yielded a lower population estimate of 123,000 pounds of pandalid shrimp with a percent error of 25.9 (Table 2). By stratum the mean commercial pandalid shrimp catches were 10.9, 17.1, 13.3 and 1.4 pounds per tow for the east closed, east open, near west and far west, respectively (Table 4).

The catch by station of pandalid shrimp is shown on Figure 4 and Table 7. The largest catches of 52, 33 and 32 pounds were in the east open stratum stations N-21, N-22 and O-22. The near west stratum had catches of 33, 29, 22 and 20 pounds in stations K-14, K-16, L-16 and L-17. The east closed only had two stations with catches over 10 pounds, T-26 (35 pounds) and U-27 (15 pounds). Tutka Bay and Sadie cove had pandalid shrimp catches of 78 and 6 pounds.

The predominant pandalid shrimp species for all strata was pink shrimp. The far west stratum catch was 100 percent pink shrimp. The near west stratum was 88.7 percent pink, 11.0 percent sidestripe and 0.3 percent humpy. The east open stratum was 95.0 percent pink, 3.1 percent coonstripe, 1.1 percent sidestripe and 0.8 percent humpy. The lowest pink shrimp percentage was 69.7 percent in the east closed strata, succeeded by 19.2 percent coonstripe, 10.5 percent humpy and 0.6 percent sidestripe shrimp (Table 7).

The pink shrimp counts per pound from field measurements by stratum were: 135.3 for the east open, 130.6 east closed and 154.8 for the combined near and far west strata (Table 6).

The mean fish and non-shrimp catch for all stations (minus Tutka Bay and Sadie Cove) was 545.7 pounds, yielding an unstratified population estimate of 9.32 million pounds with an error of 9.9 percent and a stratified population estimate of 8.99 million pounds with an error of 11.8 percent (Table 3).

Figure 5 shows the fish and non-shrimp catch by station. As in the spring 1992 survey no population estimates were done by fish species. However the predominant fish species were walleye pollock and flathead sole. Arrowtooth flounder (*Atheresthes stomais*), dusky rockfish (*Sebastes ciliatus*), starry flounder (*Platichthys stellatus*), skate (*Raja* sp.), halibut, pacific cod, sablefish (*Anoplopoma fimbria*) and Tanner crab were also caught. There were five stations with fish and non-shrimp catches of over one thousand pounds, the largest was 2,277 pounds in Tutka Bay. The next four in order were: K-9 1,188 pounds, H-18 (Sadie Cove) 1,152 pounds, H-14 1,074 pounds and O-24 1,030 pounds. Appendices H through L contain a more detailed fish and invertebrate species composition by stratum.

DISCUSSION

Stratification of the pandalid shrimp estimates reduced the percent error thereby increasing the confidence in the population estimates (Table 2). This is true especially when the shrimp distribution is concentrated or clumped in one or two strata. This occurred in 1984 through 1990 for both spring and fall surveys. When shrimp are evenly distributed throughout Kachemak Bay, stratification of the data may not be necessary. This may occur when the shrimp stocks recover to numbers of the late 1970's and early 1980's.

Stratification of the fish and non-shrimp population estimates was not as advantageous. Because fish are evenly distributed throughout Kachemak Bay, stratification was not beneficial. However by pooling all animals into one group, the clumped distribution of an individual specie may be masked and any benefit of stratification missed. One solution to this problem is to compare stratified and unstratified population estimates for the major species such as walleye pollock and flathead sole.

The overall downward trend in the pandalid shrimp population has continued in both the spring 1992 and 1993 surveys. The spring 1993 survey was the lowest mean catch per station of shrimp since the survey began. The NMFS 1993 pandalid shrimp survey of Pavlof Bay also had the lowest pandalid shrimp catch since their survey began, (P. Anderson, NMFS, P.O. Box 1638, Kodiak, Alaska 99615, personal communication).

Figure 6 illustrates the trends in the Kachemak Bay pandalid shrimp populations. The spring stratified pandalid shrimp estimate peaked in 1978 at 13 million pounds. The fall estimates peaked in 1980 at 27 million pounds. Since the peak, both the spring and fall pandalid populations declined to the present low, with a slight upward trend in spring 1984, 1988 and 1990 stratified estimates and the fall 1987 stratified estimate. On the other hand, fish populations had an inverse relationship to the shrimp with the peak spring fish stratified estimate occurring in 1988 and fall estimate peaking the next year, 1989.

Fish and non-shrimp populations that were catchable in the 61 foot high opening NMFS net have increased from a mean catch in spring surveys of 82.8 pounds per nautical mile in 1980 to a high of 660.3 pounds in 1988. The mean fish catch has remained in the 500 to 600 pound range since the spring 1988. Overall the shrimp population has declined while the fish and non-shrimp have increased.

One possible explanation is that in 1986 predation exceeded pandalid shrimp production due to consumption of shrimp by high fish numbers (walleye pollock and flathead sole). Humpy shrimp and crabs were a significant part of the diet of walleye pollock, Pacific cod and sculpins of the western Bering Sea (Zgurovsky et.al., 1989). Similar consumption of pandalid shrimp may have occurred in Kachemak Bay.

Another possible explanation for the reduction in the pandalid shrimp populations is competition for food from the fish populations. Anderson (1981) found age 0 and one plus walleye pollock stomachs contained macronekton and other small organisms found in the water column. This led him to theorize that in addition to the predator prey relationship, there may be a competition relationship between pandalid shrimp and walleye pollock. This may have happened in Kachemak Bay between the most numerous fish specie, walleye pollock and pandalid shrimp. Although there is limited research on flathead sole food habits there may also either be some competition or predation between flathead sole and pandalid shrimp. Furthermore it is possible that other species could replace the niche pandalid shrimp held in the ecosystem.

A third possible explanation for the shrimp decline is that from 1978 to 1982 the commercial fishery harvested 16 to 78 percent of the spring stratified pandalid shrimp estimates. This high fishing mortality in shrimp combined with the increasing fish populations and changing environmental conditions may have resulted in a decline in the pandalid shrimp populations (Figure 7).

Without a substantial increase in pandalid shrimp combined with a reduction of the walleye pollock, other predators and competitor populations, the likelihood of a recovery of the Kachemak Bay pandalid shrimp stock is several years away. In the future, harvest rates should never approach the high levels as those in the years 1977 to 1983 when harvest rates were 16 to 78 percent of the pandalid shrimp population estimates. Harvest rates should be very conservative; no greater than the 10 to 20 percent of the pandalid shrimp estimates. Herring fisheries throughout the state have successfully applied harvest rates at zero to 20 percent of the biomass estimates with minimum biomass thresholds where no fishing is permitted. The harvest rates should take into account the predator and competitor populations. When predator and (or)

competitor numbers are increasing shrimp harvest should be reduced to zero to 5 percent of the estimated pandalid shrimp population.

In years when shrimp abundance is high with a number of strong age classes of shrimp coupled with low fish numbers, then the harvest rate could be set as high as 20 percent of the population estimate.

The goal of the low harvest rates is allow for a sustainable commercial shrimp catch. Small shrimp (high CPP) should not be harvested because this indicates a population composed of mostly small males with few mature females. Pandalid shrimp are protandric hermaphrodites (act as both sexually mature males when small and females when large) and are subject drastic reduction in population abundance caused by removal of large females by fisheries and predators. This is amplified when small shrimp (males weighing less) are also removed there by further reducing the reproductive potential for the future.

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Table 1. Historical trawl shrimp catches by guideline harvest level for the Kachemak Bay trawl shrimp fishery in the Cook Inlet Management Area (H).

SEASON	NUMBER OF VESSELS	CATCH (lbs) JUN 1-OCT 31	NOV 1-MAR 31	APR 1-MAY 31	TOTAL
1969-70[a]	7	1,289,656	1,692,854	889,330	3,871,840
1970-71[a]	3	3,211,924	2,076,228	617,836	5,905,988
1971-72[a]	7	2,618,630	1,761,569	140,707	4,520,906
1972-73[a]	10	2,772,422	2,109,660		4,882,082
1973-74[b]	13	2,502,154	2,323,780		4,825,934
1974-75	4	2,512,764	2,519,148		5,031,912
1975-76	4	1,997,563	2,421,456		4,419,019
1976-77	5	2,545,885	2,453,101		4,998,986
1977-78	7	2,490,969	2,546,977		5,037,946
1978-79	6	2,952,733	3,060,066		6,012,799
		JUL 1-SEP 30	OCT 1-DEC 31	JAN 1-MAR 31	
1979-80	7	2,013,298	2,052,646	1,731,483	5,797,427
1980-81	15	1,780,298	2,691,746	1,704,706	6,177,129
1981-82	23	1,614,868	1,686,781	1,693,850	4,995,499
1982-83	15	998,522	1,012,388	1,009,857	3,020,767
1983-84	10	CLOSED	CLOSED	525,508	525,508
1984-85	10	519,651	528,506	518,529	1,566,686
1985-86	5	488,606	257,782	503,340	1,249,728
1986-87	3	504,206	CLOSED	CLOSED	504,206
1987-88	0	CLOSED	CLOSED	CLOSED	0
1988-89	0	CLOSED	CLOSED	CLOSED	0
1989-90	0	CLOSED	CLOSED	CLOSED	0
1990-91	0	CLOSED	CLOSED	CLOSED	0
1991-92	0	CLOSED	CLOSED	CLOSED	0
1992-93	0	CLOSED	CLOSED	CLOSED	0

[a]Catches listed for comparative purposes by seasons established in 1973.
[b]June 1 - October 31 and November 1 - March 31 seasons with respective guidelines established.

Table 2. Pandalid shrimp population estimates comparing unstratified and stratified population estimators from the Kachemak Bay trawl shrimp survey, 1977–93.

SPRING

Year	Mean catch of all stations (lbs.)	Number of stations n	–Unstratified– estimate (million lbs.)	% error	–Stratified– estimate (million lbs.)	% error	Difference in % error	Commercial harvest (lbs.)
1977	407.9	40	6.82	16.9	6.45	14.8	2.1	5,037,946
1978	810.9	36	13.55	24.9	13.36	23.6	1.3	6,012,799
1979	743.9	41	12.43	20.6	12.26	22.0	-1.4	5,797,427
1980	500.9	40	8.37	17.5	8.06	18.6	-1.1	6,177,129
1981	486.1	37	8.12	18.2	7.17	14.9	3.3	4,995,499
1982	306.7	38	5.13	21.5	4.50	17.7	3.8	3,020,767
1983	204	37	3.41	24.5	3.28	15.5	9.0	525,508
1984	282.3	34	4.72	33.8	4.26	13.8	20.0	1,566,686
1985	221.7	34	3.70	39.2	3.49	15.1	24.1	1,249,728
1986	157.2	34	2.63	50.2	2.47	38.0	12.1	504,206
1987	178.9	34	2.99	44.5	2.69	16.3	28.2	0
1988	247.5	33	4.14	44.3	3.67	15.5	28.8	0
1989	119.5	39	2.04	59.8	1.73	43.6	16.2	0
1990	220.9	41	3.77	74.3	3.27	70.7	3.6	0
1991	83	41	1.42	36.7	1.11	29.3	7.4	0
1992	72.9	36	1.25	22.2	0.90	20.7	1.5	0
1993	10.4	35	0.18	26.9	0.12	25.9	1.0	0
Avg.	297.34		4.98		4.63546		1977–93	2,052,217
							1977–86	3,488,770

FALL

Year	Mean catch of all stations (lbs.)	Number of stations n	–Unstratified– estimate (million lbs.)	% error	–Stratified– estimate (million lbs.)	% error	difference in % error	Commercial harvest (lbs.)
1977	738.4	36	12.34	28.5	10.67	25.5	3.1	5,037,946
1978	1160.3	32	19.39	25.1	17.20	27.7	-2.6	6,012,799
1979	1133.3	32	18.94	22.9	18.33	23.9	-1.0	5,797,427
1980	1689.4	37	28.23	19.1	27.19	21.4	-2.3	6,177,129
1981	604.8	35	10.11	26.5	9.71	29.2	-2.7	4,995,499
1982	519.2	36	8.68	25.9	8.22	17.9	8.0	3,020,767
1983	481.3	36	8.04	36.1	7.82	11.2	24.9	525,508
1984	532	35	8.89	26.0	7.47	13.8	12.1	1,566,686
1985	284.9	34	4.76	31.4	4.18	11.4	20.0	1,249,728
1986	153.6	34	2.57	37.4	2.35	18.0	19.4	504,206
1987	227	34	3.79	65.1	3.52	48.9	16.3	0
1988	161.9	35	2.77	50.7	2.05	32.7	18.0	0
1989	131.1	40	2.24	32.4	1.62	17.5	14.9	0
1990	104.5	42	1.78	44.7	1.50	24.3	20.5	0
Avg.	565.84		9.466		8.70257			

Table 3. Fish population estimates comparing unstratified and stratified population estimators from the Kachemak Bay trawl shrimp survey, 1977–93.

SPRING

Year	Mean catch of all stations (lbs.)	Number of stations n	–Unstratified– estimate (million lbs.)	% error	–Stratified– estimate (million lbs.)	% error	Difference in % error
1977	104.5	37	1.75	26.7	1.83	9.3	17.4
1978	150.5	31	2.51	18.7	2.63	8.1	10.7
1979	157.3	41	2.63	17.0	2.53	11.5	5.4
1980	82.9	34	1.38	17.2	1.47	11.6	5.6
1981	262.8	36	4.39	19.5	4.28	25.8	–6.3
1982	(no data)	34					
1983	132	37	2.21	20.2	2.16	26.0	–5.9
1984	179.1	34	2.99	14.1	3.15	10.7	3.4
1985	293.9	34	4.91	38.6	5.38	13.7	24.9
1986	243.4	34	4.07	38.9	4.06	46.8	–8.0
1987	215.2	34	3.60	21.7	3.37	25.2	–3.5
1988	660.3	33	11.03	8.4	10.83	9.0	–0.7
1989	554.8	39	9.48	23.5	9.71	29.7	–6.2
1990	516.1	41	8.82	11.7	7.59	13.5	–1.8
1991	642.3	41	10.98	11.3	10.60	11.0	0.3
1992	598.8	36	10.23	13.4	8.62	10.8	2.6
1993	545.7	35	9.32	9.9	8.99	11.8	–1.9
Average			5.64		5.45		

FALL

Year	Mean catch of all stations (lbs.)	Number of stations n	–Unstratified– estimate (million lbs.)	% error	–Stratified– estimate (million lbs.)	% error	Difference in % error
1977	177.4	36	2.96	17.4	2.69	17.9	–0.6
1978	471.2	24	7.87	23.4	7.22	34.5	–11.1
1979	267.3	29	4.48	22.8	4.18	26.9	–4.1
1980	402.4	32	6.72	18.0	6.27	23.9	–5.9
1981	507.2	28	8.47	19.2	8.35	28.5	–9.3
1982	664.4	32	11.10	22.4	9.65	33.5	–11.1
1983	705.6	32	11.79	17.9	10.74	16.2	1.7
1984	475	35	7.94	23.2	6.97	24.9	–1.7
1985	927.8	34	15.50	27.9	17.21	7.3	20.6
1986	259.3	34	4.33	19.7	3.93	22.3	–2.7
1987	1004.9	34	16.79	16.9	16.25	20.5	–3.6
1988	1048	35	17.91	14.6	16.07	22.0	–7.4
1989	1160.1	40	19.82	12.5	21.46	13.6	–1.2
1990	1050.3	40	17.95	14.1	15.55	21.7	–7.6
Average			10.97		10.467		

Table 4. Mean pounds of pandalid shrimp per nautical mile tow, by stratum, 1977–93.

SPRING SURVEYS

YEAR	East Closed	East Open	Near West	Far West
1977	585.2	772.2	495.7	214.4
1978	541	1420.5	621.2	801.8
1979	474	718.1	858	744.1
1980	283.7	648.7	586	458.3
1981	572.3	590.8	836.5	207.3
1982	230.7	524.8	556.5	118.5
1983	521.3	543.6	195.8	42.4
1984	694.6	1181	127.4	0
1985	786	886	5.8	0
1986	657.4	502.8	4.5	0
1987	976	150	54.5	0
1988	1334.4	173	88.8	0
1989	729.3	22.3	5.5	0.1
1990	1311.7	103.7	12.9	0.4
1991	337.2	92.5	34.3	1.3
1992	105.6	114.6	73.4	16.5
1993	10.9	17.1	13.4	1.4

FALL SURVEYS

YEAR	East Closed	East Open	Near West	Far West
1977	731.3	961.2	1595.4	189.4
1978	309.7	863.3	1895.5	1425.6
1979	376.9	616.2	1540.2	1127.5
1980	996.3	1824.2	2027.2	1594.4
1981	378.3	623.7	759.9	556.1
1982	1012	1431.8	550.2	143.8
1983	2101.6	1322.5	152.9	0
1984	897.4	1545.8	715.5	5.3
1985	612.8	1101.5	201.7	0
1986	445.2	636.3	37.6	0
1987	1403.8	162.3	4.5	0
1988	834	63.9	2.3	0
1989	499.8	197	6.8	0.5
1990	572.5	78.6	2.5	0.4
1991	Fall survey discontinued			
1992	Fall survey discontinued			
1993	Fall survey discontinued			

Table 5. Catches by station and strara, in pounds per nautical mile, in the Southern District (Kachemak Bay), spring index survey, May 19 through 28, 1992.

Far West Strata		Shrimp								Fish		Total
	Depth range						Total	Total commercial	Percent of		percent	Catch
Station	Fathoms	Pink	Humpy	Coon	Side	Other	shrimp	pan. shrimp	Total catch	fish	total catch	
H–7 a	47–49	0	0	0	0	0	0	0	0.0	270	100.0	270
H–8 a	46–47	0	0	0	0	0	0	0	0.0	270	100.0	270
I–9 a	54–57	8	0	0	0	0	8	8	0.9	925	99.1	933
K–9 a	40–45	3	0	0	0	0	3	3	0.8	362	99.2	365
L–9 a	42–46	0	0	0	0	0	0	0	0.0	258	100.0	258
L–10 a	46–46	0	0	0	0	0	0	0	0.0	258	100.0	258
H–10 a	46–50	1	0	0	0	0	1	1	0.5	184	99.5	185
H–11 a	50–52	1	0	0	0	0	1	1	0.5	184	99.5	185
J–11 a	46–47	27	0	0	0	1	28	27	7.5	334	92.3	362
H–12 a	52–58	49	0	0	0	0	49	49	8.9	502	91.1	551
I–12 a	58–58	93	0	0	0	0	93	93	22.4	323	77.6	416
Total		182	0	0	0	1	183	182	4.5	3,870	95.5	4,053
Average		16.5	0	0	0	0.1	16.6	16.5		351.82		368
Percent of Pan. shrimp		100	0	0	0							
Near West Strata												
J–13	54–64	86	0	0	0	0	86	86	12.5	601	87.5	687
L–13	45–48	74	0	0	0	1	75	74	23.1	245	76.6	320
H–14	47–48	5	0	0	0	0	5	5	0.6	769	99.4	774
K–14	54–62	144	0	0	0	2	146	144	28.8	354	70.8	500
I–14	43–50	32	0	0	0	0	32	32	7.3	408	92.7	440
L–15	44–54	55	0	0	0	0	55	55	9.1	549	90.9	604
K–16	92–94	181	0	0	35	6	222	216	24.8	649	74.5	871
L–16	54–60	31	0	0	5	0	36	38	8.2	404	91.8	440
L–17	59–59	11	0	0	2	0	13	13	2.2	570	97.8	583
Total		619	0	0	42	9	670	661	12.7	4,549	87.2	5,219
Average		68.8	0.0	0.0	4.7	1.0	74.4	73.4		505.4		580
Percent of Pan. shrimp		93.6	0.0	0.0	6.4							
East Closed Strata												
Q–24	24–33	33	0	1	0	0	34	34	7.7	406	92.3	440
R–24	25–27	84	2	2	0	1	89	88	18.2	394	81.6	483
R–25	28–29	189	1	1	0	0	191	191	26.6	528	73.4	719
S–25	24–27	180	0	1	0	0	181	181	25.5	530	74.5	711
T–26	25–29	61	0	1	1	1	64	63	5.0	1193	94.9	1,257
U–27	29–30	74	0	1	2	0	77	77	4.9	1502	95.1	1,579
Total		621	3	7	3	2	636	634	12.2	4,553	87.7	5,189
Average		103.5	0.5	1.2	0.5	0.3	106.0	105.7		758.8		865
Percent of Pan. shrimp		97.9	0.5	1.1	0.5							

a One–half mile tow doubled to represent a standard one mile tow.

Table 5, page 2 of 2.

East Open Strata		Shrimp								Fish		Total
	Depth range						Total	Total commercial	Percent of		percent	Catch
Station	Fathoms	Pink	Humpy	Coon	Side	Other	shrimp	pan. shrimp	Total catch	fish	total catch	
N–21	47–52	95	0	0	5	1	101	100	11.9	742	88.0	843
N–22	42–43	178	0	0	19	0	197	197	21.2	733	78.8	930
O–21	34–35	19	0	1	0	1	21	20	2.1	936	97.8	957
O–22	37–40	306	0	0	3	0	309	309	28.0	796	72.0	1,105
O–23	35–38	190	0	0	0	0	190	190	10.9	1547	89.1	1,737
O–24	27–32	87	0	0	0	0	87	87	6.9	1178	93.1	1,265
P–21	20–23	36	1	0	0	0	37	37	23.0	124	77.0	161
P–22	31–31	88	1	1	0	0	90	90	18.1	408	81.9	498
P–23	31–32	85	0	0	0	1	86	85	9.6	802	90.3	888
Total		1114	2	3	27	3	1149	1146	11.8	8,586	88.2	9,735
Average		111.4	0.2	0.3	2.7	0.3	114.9	114.6		858.6		974
Percent of Pan. shrimp		97.2	0.2	0.3	2.4							
Tutka & Saddie												
C\D–20	44–46	241	4	17	4	3	269	266	18.8	1,143	80.9	1,412
H–18	37–47	20	0.4	2	0.2	0	22.6	22.6	2.1	1,030	97.9	1,053
Total		261	4.4	19	4.2	3	291.6	288.6	11.7	2,173	88.2	2,465
Average		130.5	2.2	9.5	2.1	1.5	145.8	144.3		1,087		1,232
Percent of Pan. shrimp		90.4	1.5	6.6	1.5							

Table 6. Historical average numbers of pink shrimp per pound by area, Kachemak Bay trawl shrimp surveys, 1971–93.

Year	Spring survey East open	Spring survey East closed	Spring survey West (near + far)	Fall survey East open	Fall survey East closed	Fall survey West (near + far)
1971	230.3	213.4	159.6			
1972	185.3	203.1	137.3			
1973	230.4	167.2	152.0			
1974	133.8	125.6	126.0			
1975	154.6	143.5	135.9			
1976	169.6	157.8	107.5	no samples	144.1	112.5
1977	144.7	142.7	109.0	no samples	164.0	144.1
1978	155.0	163.6	123.7	148.1	159.6	133.4
1979	170.7	203.3	126.6	149.8	no samples	135.0
1980	173.6	190.1	112.0	150.8	183.8	135.4
1981	193.1	190.9	111.7	112.9	182.0	127.2
1982	180.8	177.2	112.8	202.0	181.9	106.8
1983	151.3	176.2	102.6	198.9	232.7	146.2
1984	177.5	224.2	98.5	183.8	205.8	142.6
1985	193.8	244.3	199.0	190.0	246.7	247.5
1986	155.5	229.4	no samples	215.3	230.7	131.4
1987	134.8	271.4	108.5	115.0	184.0	no samples
1988	107.5	247.3	95.0	109.5	146.5	83.1
1989	121.3	197.7	85.0	145.3	188.8	92.0
1990	132.3	170.8	94.5	134.0	16.0	77.5
1991	108.1	163.7	130.6			
1992	143.9	154.5	158.6			
1993	135.3	130.6	154.8			

Table 7. Catches by station and strata, in pounds per nautical mile, in the Southern District (Kachemak Bay) spring index survey, May 17 through 21, 1993.

Far West Strata / Station	Depth range	Shrimp: Pink	Humpy	Coon	Side	Other	Total shrimp	Total commercial pan. shrimp	Percent of total catch	Fish: Fish	Fish: percent total catch	Total Catch (Bio. Mas)
H–7 a	44–46	0	0	0	0	0	0	0	0.0	325	100.0	325
H–8 a	44–46	0	0	0	0	0	0	0	0.0	325	100.0	325
K–9 a	38–43	0	0	0	0	0	0	0	0.0	1,188	100.0	1,188
L–9 a	43–45	0	0	0	0	0	0	0	0.0	504	100.0	504
L–10 a	43–45	0	0	0	0	0	0	0	0.0	504	100.0	504
H–10 a	45–52	0	0	0	0	0	0	0	0.0	204	100.0	204
H–11 a	45–52	0	0	0	0	0	0	0	0.0	204	100.0	204
J–11 a	43–45	0	0	0	0	0	0	0	0.0	660	100.0	660
H–12 a	60–60	5.9	0	0	0	0.1	6	5.9	1.5	375	98.4	381
I–12 a	56–56	2.1	0	0	0	0.1	2.2	2.1	0.5	462	99.5	464
Total		8	0	0	0	0.2	8.2	8	0.2	4,751	99.8	4,759
Average		0.8	0	0	0	0.02	0.82	0.8		475.1		476
Percent of Pan. shrimp		100	0	0	0							
Near West Strata												
J–13	54–63	4.2	0	0	0	0.1	4.3	4.2	0.9	442	99.0	446
L–13	45–48	3.3	0	0	0.4	0.1	3.8	3.7	0.4	827	99.5	831
H–14	47–49	1.9	0.2	0	0	0.8	2.9	2.1	0.2	1,074	99.7	1,077
K–14	53–61	31	0	0	2	0	33	33	4.4	714	95.6	747
I–14	31–52	0.8	0	0	0	0.1	0.9	0.6	0.3	315	99.7	316
L–15	54–63	7.1	0	0	0	0.1	7.2	7.1	2.2	312	97.7	319
K–16	91–94	25.6	0.1	0	2.8	1.5	30	28.5	5.7	467	94.0	497
L–16	57–59	17	0	0	4.9	0.6	22.5	21.9	2.9	724	97.0	747
L–17	61–64	16.4	0.1	0	3.2	0.1	19.6	19.7	3.3	584	96.7	604
Total		107.3	0.4	0	13.3	3.4	124.4	121	2.2	5,459	97.8	5,583
Average		11.9	0.0	0.0	1.5	0.4	13.8	13.4		606.6		620
Percent of Pan. shrimp		88.7	0.3	0.0	11.0							
East Closed Strata												
Q–24	28–35	0.4	0.2	1.2	0	0.6	2.4	1.8	0.5	389	99.4	391
R–24	27–27	0.9	0.1	0.1	0	0.5	1.6	1.1	0.2	716	99.8	718
R–25	30–30	4.4	0.1	0.3	0	0.6	5.4	4.8	0.7	667	99.2	672
S–25	29–29	7.7	0.5	0.3	0	1.3	9.8	8.5	1.2	727	98.7	737
T–26	27–35	22.5	5.8	6	0.4	6	40.7	34.7	5.9	544	93.0	585
U–27	32–32	9.6	0.2	4.7	0	0.3	15	14.7	2.2	659	97.8	674
Total		45.7	6.9	12.6	0.4	9.3	74.9	65.6	1.7	3,702	98.0	3,777
Average		7.6	1.2	2.1	0.1	1.6	12.5	10.9		617.0		629
Percent of Pan. shrimp		69.7	10.5	19.2	0.6							

a One–half mile tow doubled to represent a standard one mile tow.

Table 7, page 2 of 2.

East Open Strata	Depth range	Shrimp								Fish		Total Catch (Bio. Mas)
		Pink	Humpy	Coon	Side	Other	Total shrimp	Total commercial pan. shrimp	Percent of total catch	Fish	percent total catch	
N–20	37–37	13.9	0.2	0.2	0.2	0.1	14.6	14.5	3.1	450	96.9	465
N–21	44–46	52.1	0	0	0.2	1.5	53.8	52.3	9.6	492	90.1	546
N–22	39–41	31.3	0	0.1	1.5	0	32.9	32.9	12.2	236	87.8	269
O–21	33–34	5.3	0.1	0.3	0	1.1	6.8	5.7	0.6	977	99.3	984
O–22	38–41	31.9	0	0	0	0.2	32.1	31.9	7.9	371	92.0	403
O–23	33–36	10.4	0.4	0.2	0	0.4	11.4	11	2.5	423	97.4	434
O–24	26–34	1.4	0.1	1.1	0	1.9	4.5	2.6	0.3	1,030	99.6	1,035
P–21	20–22	0	0.14	2.9	0	0.46	3.5	3.04	1.1	269	98.7	273
P–22	31–33	6.75	0.23	0.52	0	0.92	8.42	7.5	2.2	335	97.5	343
P–23	30–30	9.3	0.2	0	0	3.1	12.6	9.5	1.5	603	98.0	616
Total		162.4	1.4	5.3	1.9	9.7	180.6	170.9	3.2	5,186	96.6	5,367
Average		16.2	0.1	0.5	0.2	1.0	18.1	17.1		518.6		537
Percent of Pan. shrimp		95.0	0.8	3.1	1.1							
Tutka & Saddle												
C\D–20	38–45	65.9	1.9	8	1.9	0	77.7	77.7	3.3	2,277	96.7	2,355
H–18	35–52	4.2	1.2	0.4	0	0.3	6.1	5.8	0.5	1,153	99.5	1,159
Total		70.1	3.1	8.4	1.9	0.3	83.8	83.5	2.4	3,430	97.6	3,514
Average		35.05	1.55	4.2	0.95	0.15	41.9	41.75		1,715		1,757
Percent of Pan. shrimp		84.0	3.7	10.1	2.3							

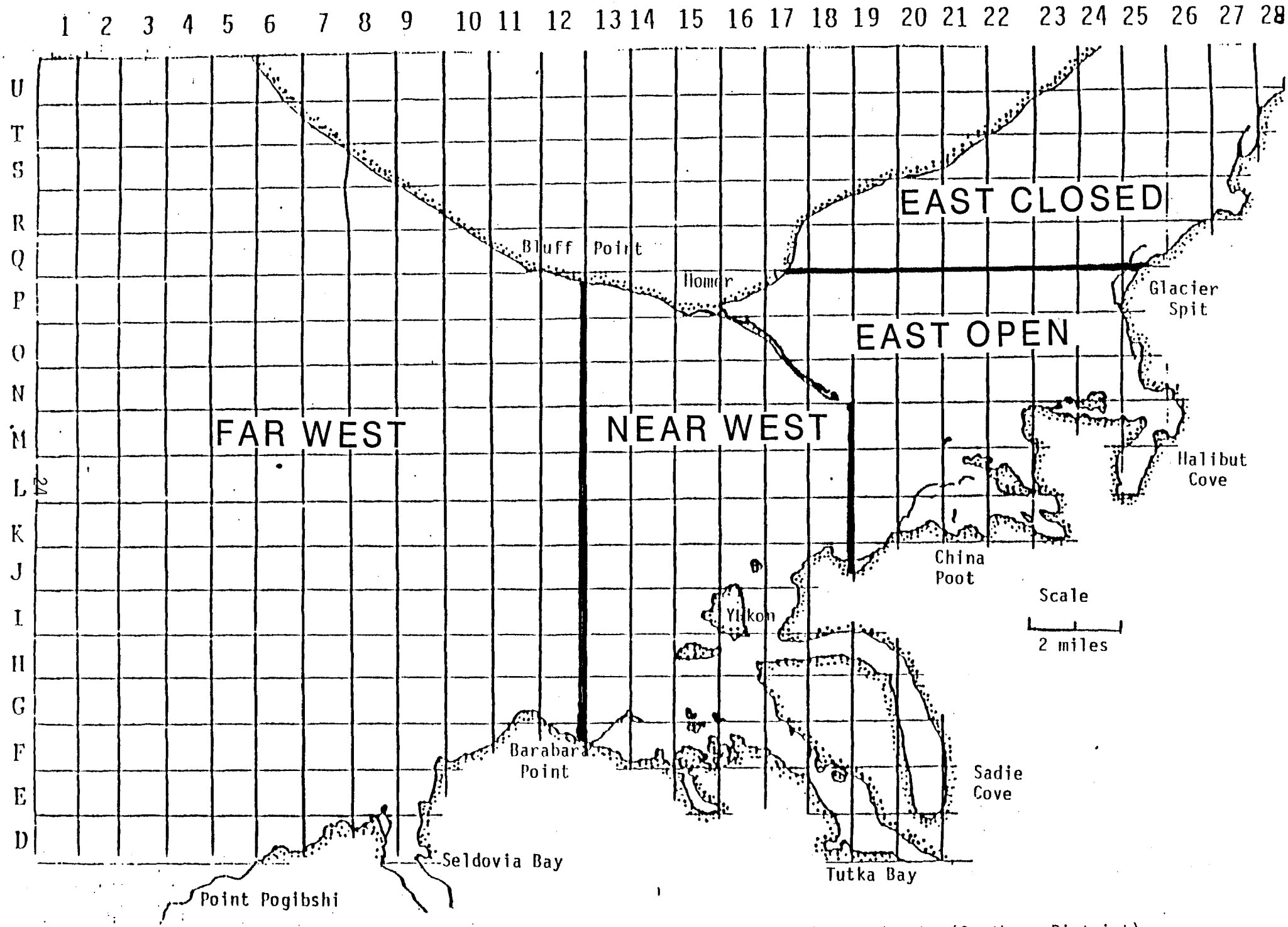

Figure 1. Location of the strata for the stratified population estimates in the (Southern District) Kachemak Bay trawl shrimp survey, 1977 to 1993.

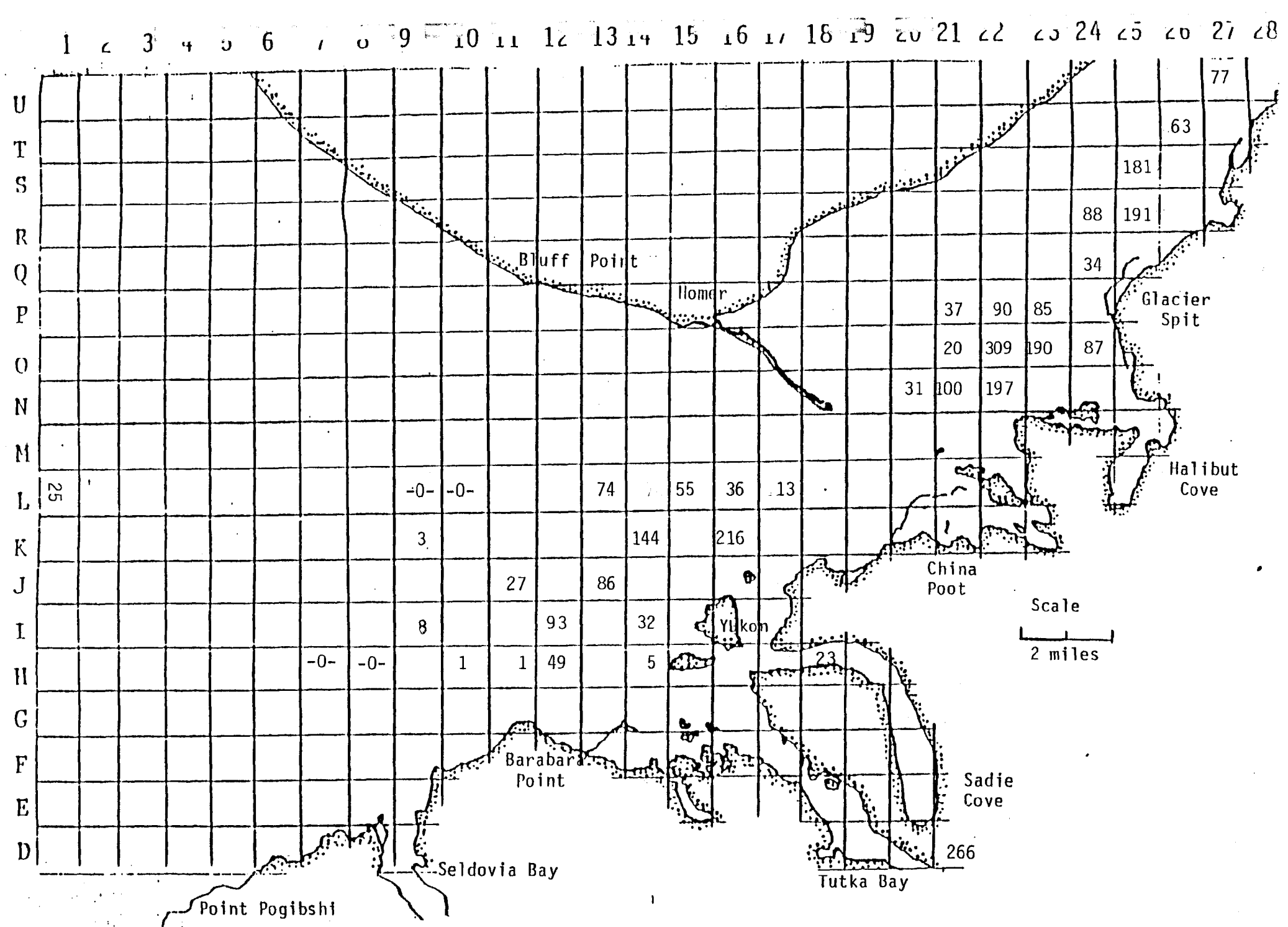

Figure 2. Kachemak Bay shrimp trawl survey catches in pounds of commercial pandalid shrimp per one mile tow, May 19 through May 28, 1992.

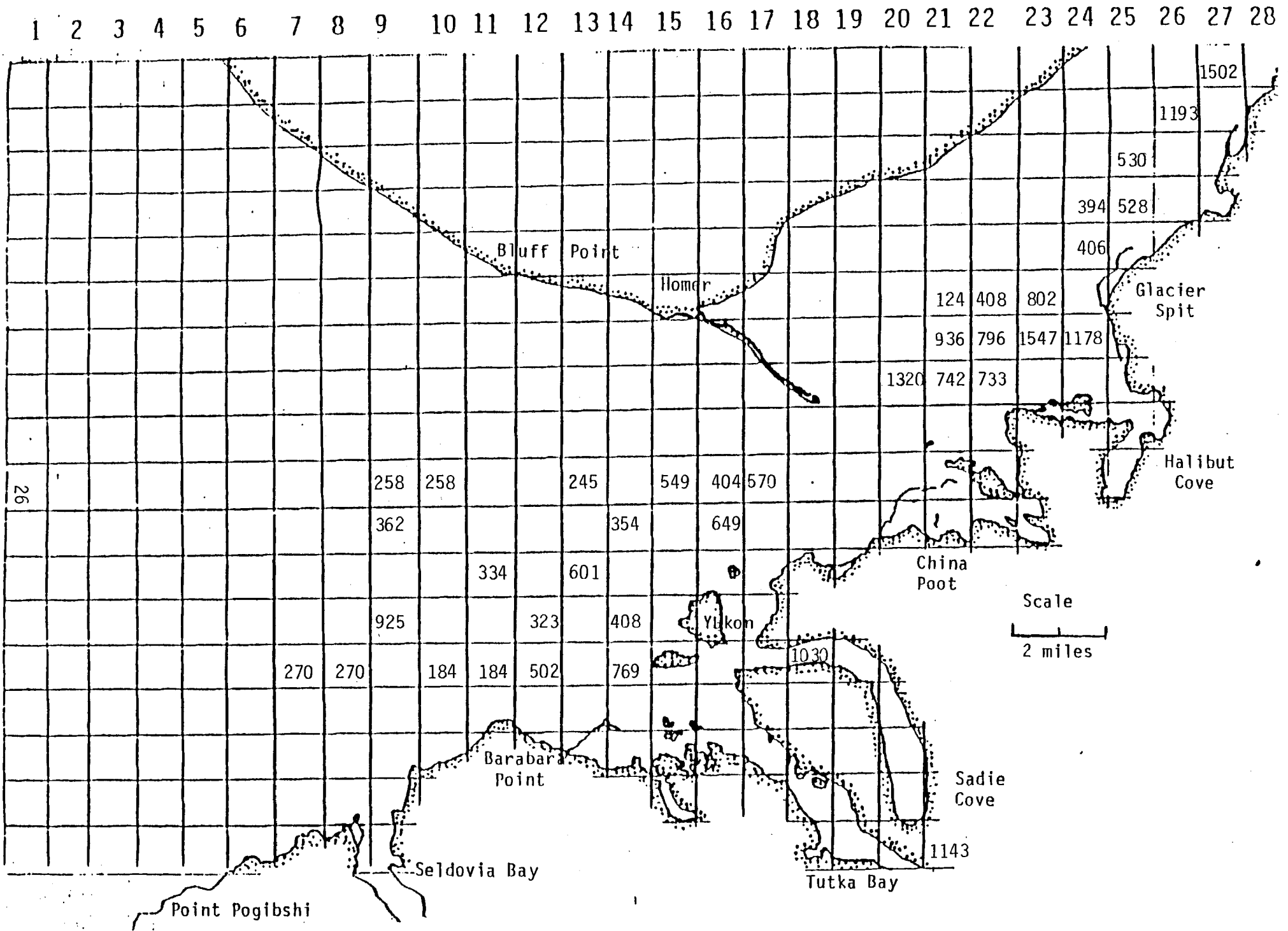

Figure 3. Kachemak Bay shrimp trawl survey catches in pounds of fish and non-shrimp intertebrates per one nautical mile tow, May 19 through May 28, 1992.

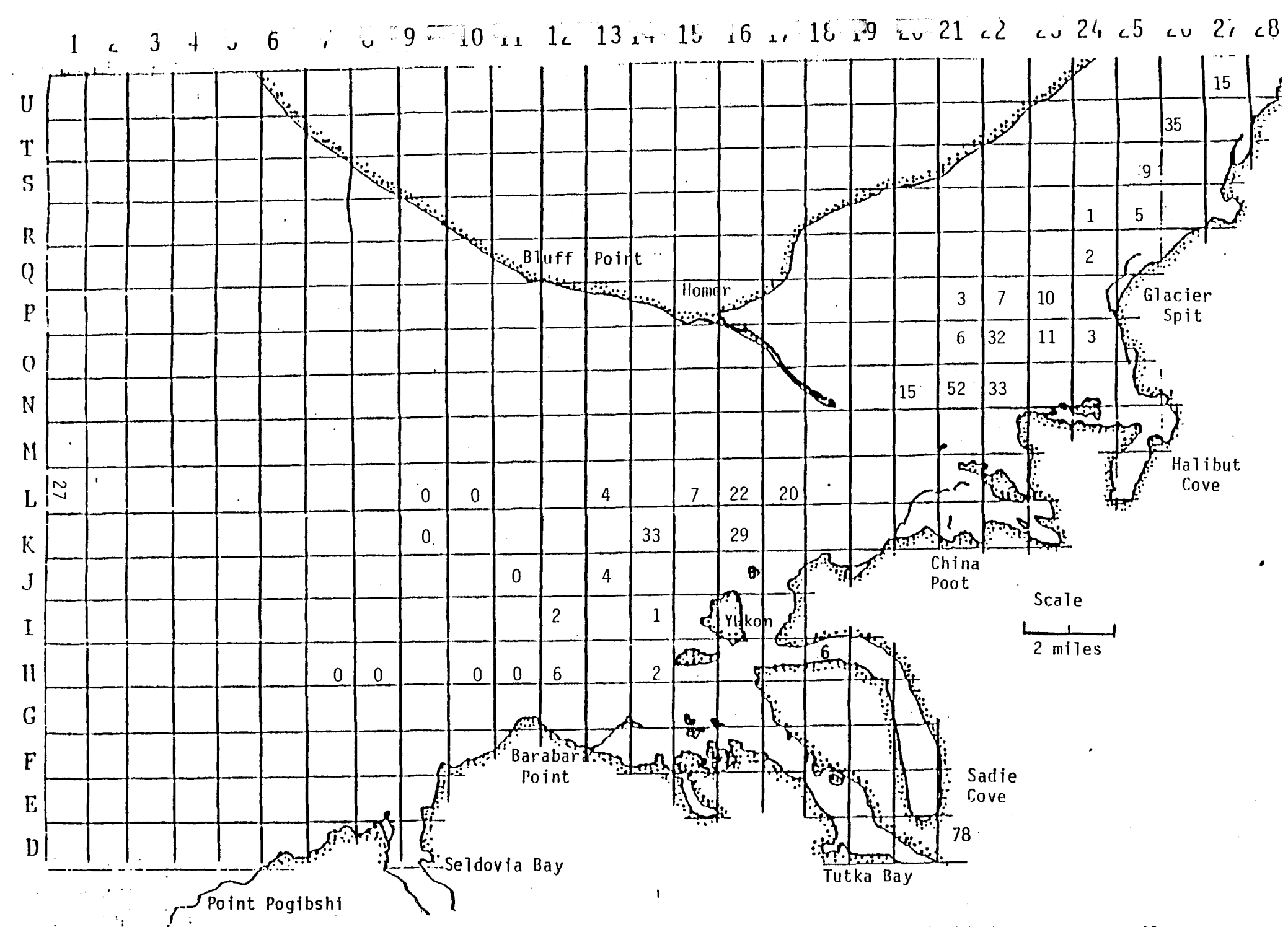

Figure 4. Kachemak Bay shrimp trawl survey catches in pounds of commercial pandalid shrimp per one mile tow, May 17 through May 26, 1993.

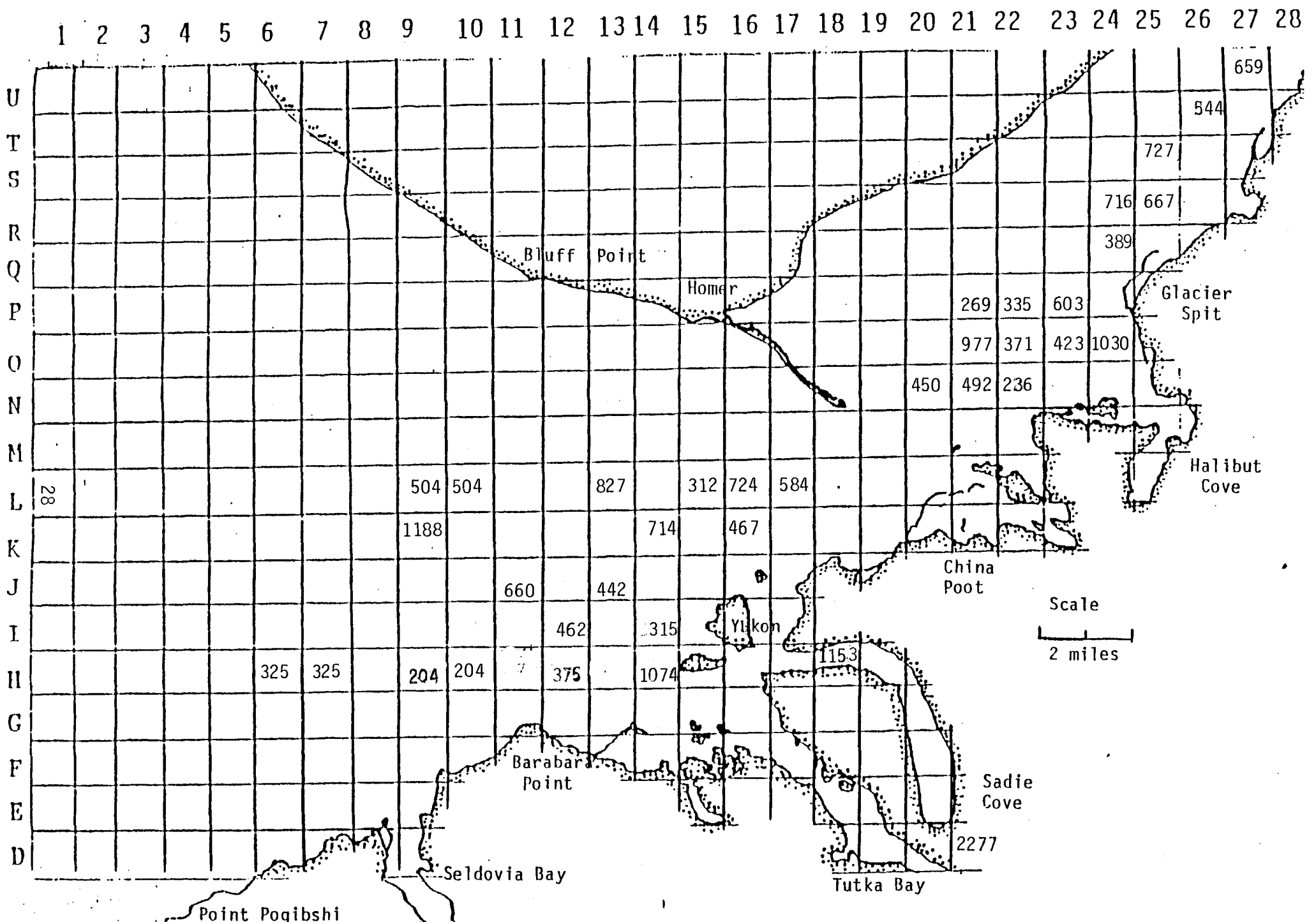

Figure 5. Kachemak Bay shrimp trawl survey catches in pounds of fish and non-shrimp invertebrates per one mile tow, May 17 through May 26, 1993.

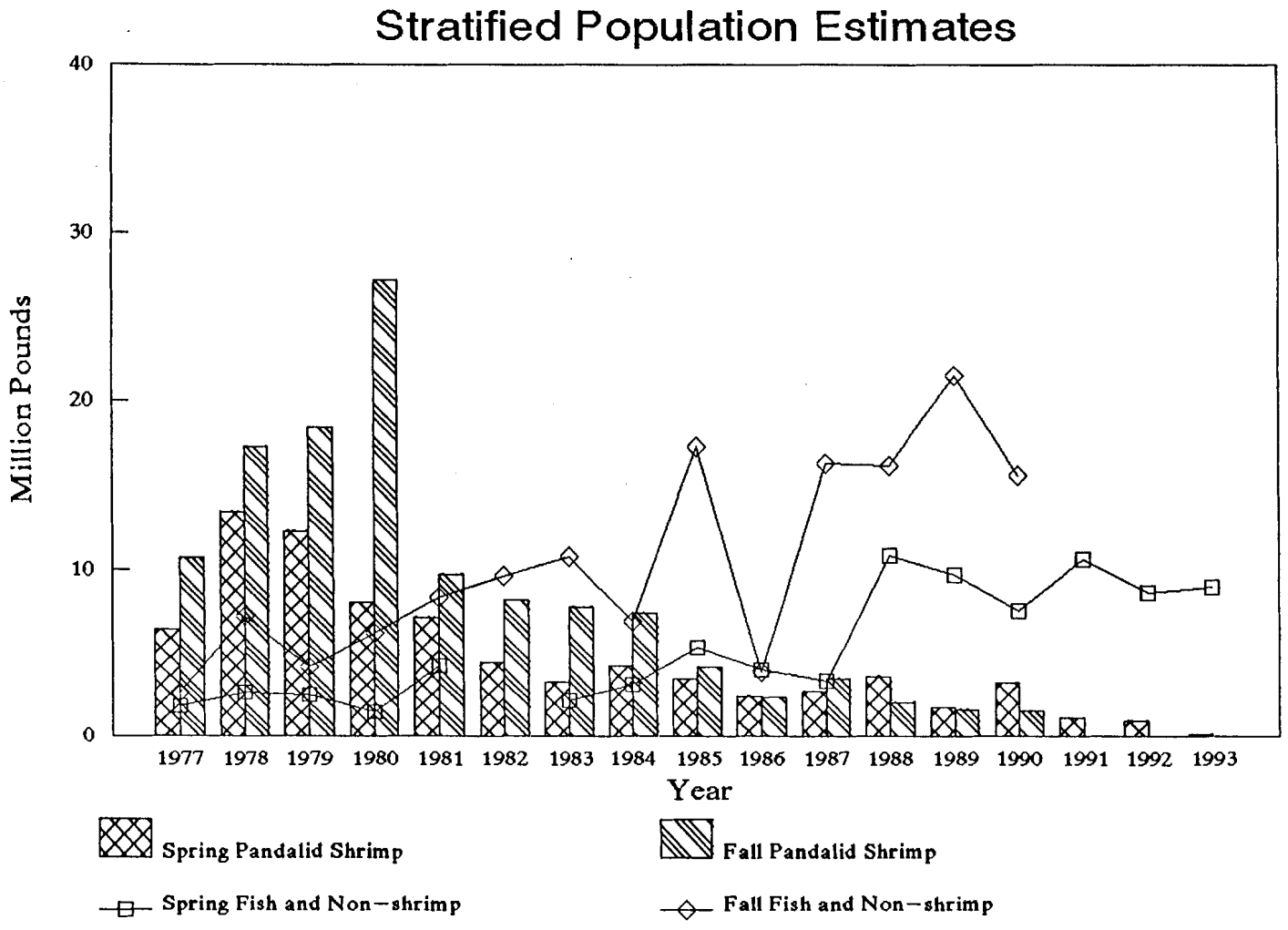

Figure 6. Stratification of the Kachemak Bay trawl shrimp survey data for the pandalid shrimp, and fish and non−shrimp populations, from 1977 to 1993.

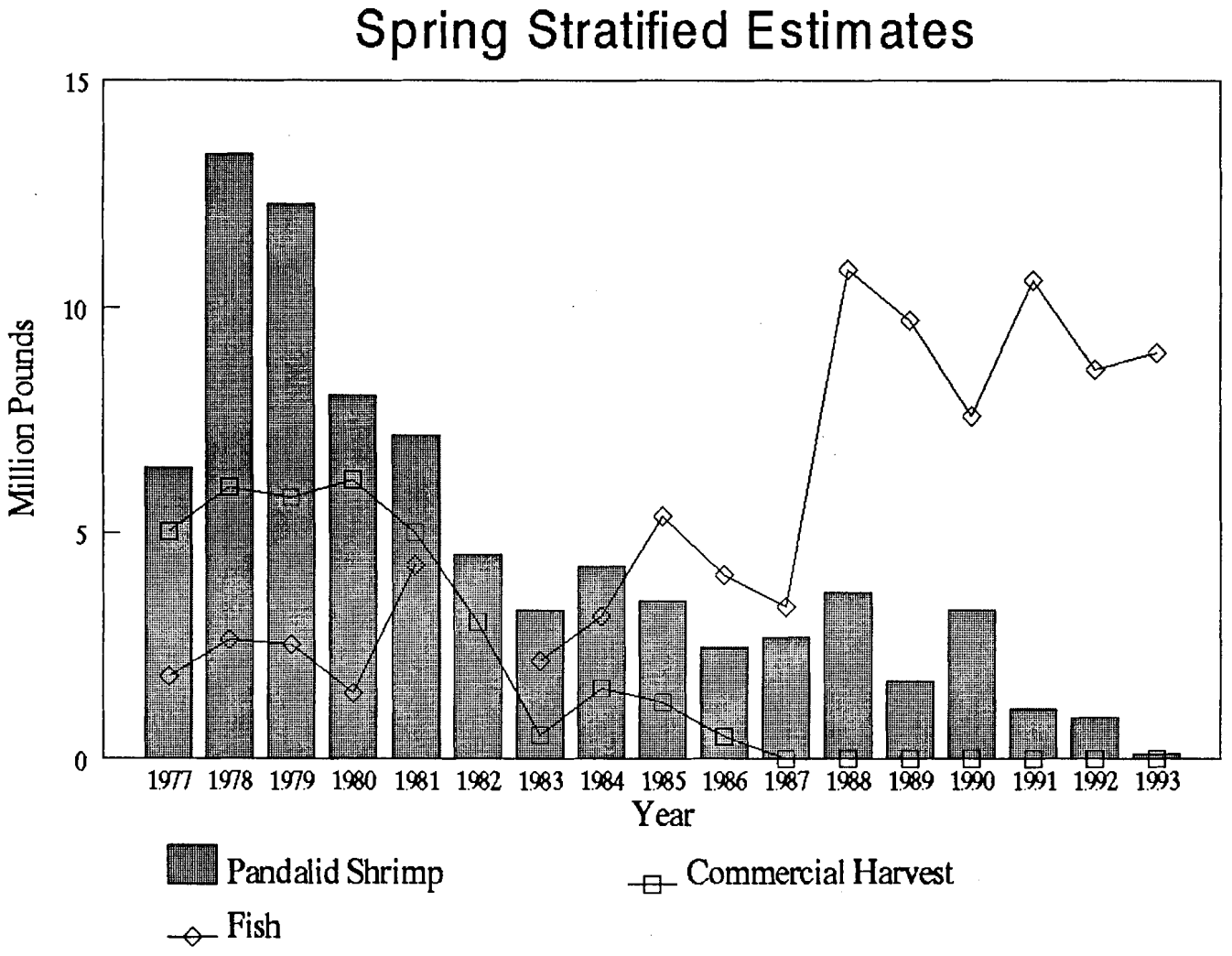

Figure 7. Spring stratified pandalid shrimp estimates with the commercial harvest and spring stratified fish estimates, from 1977 to 1993.

Appendix A. Formulas and explanations for calculations of unstratified abundance estimate and range for pandalid shrimp in the Southern District of the Cook Inlet Management Area (H).

$$\text{Mean shrimp catch} = \frac{\sum_{i=1}^{N} x_i}{N} = \bar{x}$$

$$\text{Area - total } (Nm^2) \text{ considered} = A$$

$$\text{Total number of tows} = N$$

$$\text{Sample variance } (SV) = \frac{1}{N-1}\sum_{i=1}^{N} (x_i - \bar{x})^2$$

where $x_1, x_2, \ldots, x_N$ are the standardized (1 Nm) catches of shrimp from each tow.

$$\text{Standard deviation } (SD) = \sqrt{SV}$$

$$\text{Standard error of the mean } (SE) = \frac{SD}{\sqrt{N}}$$

$$\text{Population estimate } (p) = \left(\frac{6076}{32} \times A\right) \bar{x}$$

$$\text{Standard deviation of the population estimate } (Sp) = \left(\frac{6076}{32} \times A\right) SE$$

$$\text{Percent error} = \frac{1.3 \times SE}{\bar{x}} \times 100$$

Notes: 6,076 is the number of feet in a nautical mile; 32 is the effective width of the net; 88 is the area of the stratum A in square nautical miles 1977 through spring 1988; 90 is the area for the stratum A in square nautical miles fall 1988 through spring 1993; and $\bar{x}$ is the mean catch.

Percent error: 1.3 is the value from the normal distribution statistical table giving an approximate 80% confidence interval.

Source: Watson, Leslie. 1981. Shrimp trawl survey manual. May 1, 1981. ADF&G, Kodiak, AK. 44 pp.

Appendix B. Formulas and explanations for calculations of stratified abundance estimate and range for pandalid shrimp in the Southern District of the Cook Inlet Management Area (H).

Stratified population estimate (P_s) became:

$$P_s = \left(\frac{6076}{32}\right) \sum_{i=1}^{4} A_i \overline{X_i}$$

where A_i is the area of stratum i in nm^2. The mean catch ($\overline{X_i}$) was estimated from the standardized catch of shrimp per nm (X_{ij}) from each tow (j) averaged across the n_i tows in stratum i as:

$$\overline{X_i} = \frac{\sum_{j=1}^{n_i} X_{ij}}{n_i} .$$

The standard deviation (SD_P) of the stratified population estimate became:

$$SD_P = \left(\frac{6076}{32}\right) \sqrt{\sum_{i=1}^{4} A_i^2 \frac{S_i^2}{n_i}}$$

where S_i^2 was:

$$S_i^2 = \frac{\sum_{j=1}^{n_i} (X_{ij} - \overline{X_i})^2}{(n_i - 1)} .$$

Percent error (PE) was estimated as:

$$PE = \frac{1.3\ SD_p}{P_s}\ 100 \quad .$$

Appendix C. **Fish and non-shrimp species composition for the far west stratum's cummulative stations catch, spring 1992 survey.**

number stations	11	total	Avg.	percent
Pollock		938.9	85.35	24.26
Flathead		618.9	56.26	15.99
Arrowtooth		563.5	51.23	14.56
Dover sole		333.4	30.31	8.61
Rex sole		284.2	25.84	7.34
P. cod		193.7	17.61	5.01
Sculpins		185.7	16.88	4.80
Rockfish,		162.7	14.79	4.20
Sea anemones		122.2	11.11	3.16
T. crab		88.9	8.08	2.30
Halibut		86.5	7.86	2.24
Blackcod		57	5.18	1.47
English sole		41.2	3.75	1.06
Urchins		33.6	3.05	0.87
Cucumaria		26.4	2.40	0.68
Tomcod		19.9	1.81	0.51
Pink scallops		19.4	1.76	0.50
Parastichopous		17.6	1.60	0.45
Other crab		16.1	1.46	0.42
Eelpouts		13	1.18	0.34
Snails		12.2	1.11	0.32
spiny dogfish		10.4	0.95	0.27
Smelt		8.8	0.80	0.23
Rock sole		8.6	0.78	0.22
Jellyfish		2.8	0.25	0.07
Starfish		2.6	0.24	0.07
Prowfish		1.2	0.11	0.03
Clams		0.6	0.05	0.02
Eulochon		0	0.00	0.00
Longfin		0	0.00	0.00
Pentamera		0	0.00	0.00
Wrymouths		0	0.00	0.00
Snailfish		0	0.00	0.00
Starry flounder		0	0.00	0.00
Rainbow		0	0.00	0.00
Yellowfin sole		0	0.00	0.00
Herring		0	0.00	0.00
Searcher		0	0.00	0.00
Butter sole		0	0.00	0.00
D. crab		0	0.00	0.00
K. crab		0	0.00	0.00
		0	0.00	0.00
Pricklebacks		0	0.00	0.00
Skate		0	0.00	0.00
Sandfish		0	0.00	0.00
Squid		0	0.00	0.00
Rockfish,	Rougheye	0	0.00	0.00
Rockfish,	Dusky	0	0.00	0.00
Alaska plaice		0	0.00	0.00
Capelin		0	0.00	0.00
W.vane scallops		0	0.00	0.00
Octopus		0	0.00	0.00
Poacher		0	0.00	0.00
Debris		340.7	30.97	
Total		3870		100.00

Appendix D. Fish and non-shrimp species composition for the near west stratum's cummulative stations catch, spring 1992 survey.

number stations	9	total	Avg.	Percent
Pollock		1643.5	182.61	36.2
Flathead		1404.0	156.00	30.9
T. crab		435.6	48.40	9.6
Arrowtooth		390.5	43.39	8.6
P. cod		242.0	26.89	5.3
Sea anemones		126.8	14.09	2.8
Rockfish,		98.0	10.89	2.2
Eelpouts		67.7	7.52	1.5
Rex sole		43.0	4.78	0.9
Dover sole		25.9	2.88	0.6
Halibut		18.0	2.00	0.4
		10.0	1.11	0.2
Cucumaria		8.4	0.93	0.2
Snails		7.3	0.81	0.2
Urchins		6.7	0.74	0.1
Butter sole		6.3	0.70	0.1
Smelt		5.4	0.60	0.1
Jellyfish		1.9	0.21	0.0
Pink scallops		1.8	0.20	0.0
Pricklebacks		1.5	0.17	0.0
Sculpins		0.5	0.06	0.0
Squid		0.4	0.04	0.0
Capelin		0.3	0.03	0.0
Poacher		0.2	0.02	0.0
Rainbow		0.0	0.00	0.0
Wrymouths		0.0	0.00	0.0
K. crab		0.0	0.00	0.0
D. crab		0.0	0.00	0.0
Eulachon		0.0	0.00	0.0
Longfin		0.0	0.00	0.0
Parastichopous		0.0	0.00	0.0
Tomcod		0.0	0.00	0.0
Other crab		0.0	0.00	0.0
Blackcod		0.0	0.00	0.0
Snailfish		0.0	0.00	0.0
Prowfish		0.0	0.00	0.0
Clams		0.0	0.00	0.0
Pentamera		0.0	0.00	0.0
Rockfish,	Rougheye	0.0	0.00	0.0
W.vane scallops		0.0	0.00	0.0
Octopus		0.0	0.00	0.0
Rock sole		0.0	0.00	0.0
Alaska plaice		0.0	0.00	0.0
Searcher		0.0	0.00	0.0
Herring		0.0	0.00	0.0
Rockfish,	Dusky	0.0	0.00	0.0
English sole		0.0	0.00	0.0
Starry flounder		0.0	0.00	0.0
Skate		0.0	0.00	0.0
Starfish		0.0	0.00	0.0
Sandfish		0.0	0.00	0.0
		0.0	0.00	0.0
Yellowfin sole		0.0	0.00	0.0
Debris		333.9	37.10	
Total		4545.7		100

Appendix E. Fish and non–shrimp species composition for the east open stratum's cummulative stations catch, spring 1992 survey.

number stations	10	total	Avg.	percent
Pollock		5701	570.10	66.43
Flathead		1766.7	176.67	20.59
P. cod		321.8	32.18	3.75
Halibut		282	28.20	3.29
Arrowtooth		264.5	26.45	3.08
Sculpins		98.2	9.82	1.14
Rex sole		35.1	3.51	0.41
T. crab		31.7	3.17	0.37
D. crab		18.4	1.84	0.21
Tomcod		14.5	1.45	0.17
Sea anemones		9.6	0.96	0.11
Cucumaria		9.3	0.93	0.11
Smelt		5.1	0.51	0.06
Eelpouts		4.8	0.48	0.06
Capelin		4.3	0.43	0.05
Rockfish,		4	0.40	0.05
Pricklebacks		3.9	0.39	0.05
Yellowfin sole		3.5	0.35	0.04
Herring		3	0.30	0.03
Poacher		0.4	0.04	0.00
Squid		0.2	0.02	0.00
Starry flounder		0	0.00	0.00
Eulachon		0	0.00	0.00
Alaska plaice		0	0.00	0.00
Snails		0	0.00	0.00
Parastichopous		0	0.00	0.00
Pentamera		0	0.00	0.00
Dover sole		0	0.00	0.00
Longfin		0	0.00	0.00
Rainbow		0	0.00	0.00
Wrymouths		0	0.00	0.00
		0	0.00	0.00
Snailfish		0	0.00	0.00
Prowfish		0	0.00	0.00
Clams		0	0.00	0.00
Other crab		0	0.00	0.00
Blackcod		0	0.00	0.00
Rockfish,	Dusky	0	0.00	0.00
Rock sole		0	0.00	0.00
K. crab		0	0.00	0.00
		0	0.00	0.00
Skate		0	0.00	0.00
Searcher		0	0.00	0.00
Rockfish,	Rougheye	0	0.00	0.00
Jellyfish		0	0.00	0.00
Butter sole		0	0.00	0.00
Sandfish		0	0.00	0.00
Pink scallops		0	0.00	0.00
W.vane scallops		0	0.00	0.00
Urchins		0	0.00	0.00
Octopus		0	0.00	0.00
English sole		0	0.00	0.00
Starfish		0	0.00	0.00
Debris		101	10.10	
Total		8582		100

Appendix F. Fish and non–shrimp species composition for the east closed stratum's cummulative stations catch, spring 1992 survey.

number stations	6	total	Avg.	percent
Pollock		2520.9	420.15	55.37
Flathead		657.4	109.57	14.44
P. cod		515	85.83	11.31
Starry flounder		351.7	58.62	7.72
Halibut		181	30.17	3.98
Skate		104	17.33	2.28
Herring		89.6	14.93	1.97
Sculpins		33.7	5.62	0.74
Tomcod		32.5	5.42	0.71
Yellowfin sole		15.9	2.65	0.35
Capelin		11.3	1.88	0.25
D. crab		10.9	1.82	0.24
Arrowtooth		10.7	1.78	0.24
Smelt		6.8	1.13	0.15
Alaska plaice		5.1	0.85	0.11
Eelpouts		4.2	0.70	0.09
Starfish		1.5	0.25	0.03
Sandfish		0.8	0.13	0.02
Snailfish		0	0.00	0.00
Parastichopous		0	0.00	0.00
Jellyfish		0	0.00	0.00
Sea anemones		0	0.00	0.00
Other crab		0	0.00	0.00
Clams		0	0.00	0.00
Prowfish		0	0.00	0.00
Longfin		0	0.00	0.00
Eulochon		0	0.00	0.00
Pentamera		0	0.00	0.00
Cucumaria		0	0.00	0.00
		0	0.00	0.00
Wrymouths		0	0.00	0.00
Snails		0	0.00	0.00
Rainbow		0	0.00	0.00
Rockfish,		0	0.00	0.00
K. crab		0	0.00	0.00
		0	0.00	0.00
Rex sole		0	0.00	0.00
Dover sole		0	0.00	0.00
Rock sole		0	0.00	0.00
Butter sole		0	0.00	0.00
English sole		0	0.00	0.00
Blackcod		0	0.00	0.00
T. crab		0	0.00	0.00
Squid		0	0.00	0.00
Octopus		0	0.00	0.00
Pricklebacks		0	0.00	0.00
Searcher		0	0.00	0.00
Rockfish,	Rougheye	0	0.00	0.00
Rockfish,	Dusky	0	0.00	0.00
Pink scallops		0	0.00	0.00
W.vane scallops		0	0.00	0.00
Urchins		0	0.00	0.00
Poacher		0	0.00	0.00
		0		
Debris		120.6	20.1	
Total		4553		100

Appendix G. Fish and non–shrimp species composition for the Tutka and Sadie cummulative stations catch, spring 1992 survey.

number stations	2	total	Avg.	percent
Pollock		1222.6	611.30	56.25
Flathead		606.1	303.05	27.89
Sculpins		126.9	63.45	5.84
T. crab		104.4	52.20	4.80
Yellowfin sole		60.1	30.05	2.77
P. cod		28.5	14.25	1.31
Arrowtooth		15.6	7.80	0.72
Tomcod		4.3	2.15	0.20
Herring		4.3	2.15	0.20
Eelpouts		0.6	0.30	0.03
Parastichopous		0	0.00	0.00
Cucumaria		0	0.00	0.00
Other crab		0	0.00	0.00
Sea anemones		0	0.00	0.00
Jellyfish		0	0.00	0.00
Sandfish		0	0.00	0.00
Starfish		0	0.00	0.00
Pentamera		0	0.00	0.00
Octopus		0	0.00	0.00
		0	0.00	0.00
Snails		0	0.00	0.00
Clams		0	0.00	0.00
Prowfish		0	0.00	0.00
Snailfish		0	0.00	0.00
Smelt		0	0.00	0.00
Wrymouths		0	0.00	0.00
Eulochon		0	0.00	0.00
Rainbow		0	0.00	0.00
Longfin		0	0.00	0.00
Rockfish,		0	0.00	0.00
Squid		0	0.00	0.00
Halibut		0	0.00	0.00
Rock sole		0	0.00	0.00
Rex sole		0	0.00	0.00
English sole		0	0.00	0.00
Butter sole		0	0.00	0.00
D. crab		0	0.00	0.00
Dover sole		0	0.00	0.00
K. crab		0	0.00	0.00
Alaska plaice		0	0.00	0.00
Starry flounder		0	0.00	0.00
Blackcod		0	0.00	0.00
Urchins		0	0.00	0.00
Rockfish,		0	0.00	0.00
Searcher		0	0.00	0.00
Pink scallops		0	0.00	0.00
Capelin		0	0.00	0.00
W.vane scallops		0	0.00	0.00
Rockfish,		0	0.00	0.00
		0	0.00	0.00
Skate		0	0.00	0.00
Pricklebacks		0	0.00	0.00
Poacher		0	0.00	0.00
Debris		29.9	14.95	
Total		2173.4		100

Appendix H. Fish and non–shrimp species composition for the far west stratum's cummulative stations catch, 1993 survey.

No. of stations	10	total (lbs.)	Avg. (lbs.)	percent
Pollock		1558.5	155.85	33.16
Arrowtooth		663.4	66.34	14.12
Rockfish,	Dusky	647.8	64.78	13.79
Halibut		426	42.6	9.07
Flathead		358.6	35.86	7.63
Dover sole		245.5	24.55	5.22
Sea anemones		224	22.4	4.77
P. cod		166.4	16.64	3.54
W.vane scallops		132	13.2	2.81
Rex sole		61.7	6.17	1.31
Sculpins		45.6	4.56	0.97
T. crab		28.2	2.82	0.60
Prowfish		28	2.8	0.60
Pink scallops		27	2.7	0.57
Rockfish,	Rougheye	15	1.5	0.32
Blackcod		12	1.2	0.26
Starry flounder		12	1.2	0.26
Rock sole		12	1.2	0.26
English sole		10.2	1.02	0.22
Yellowfin sole		8	0.8	0.17
Rockfish,		4.44	0.444	0.09
Cucumaria		3.4	0.34	0.07
Urchins		2.7	0.27	0.06
Starfish		1.8	0.18	0.04
Tomcod		1.6	0.16	0.03
Eulochon		1.2	0.12	0.03
Eelpouts		1.1	0.11	0.02
Poacher		0.7	0.07	0.01
Squid		0.4	0.04	0.01
Smelt		0	0	0.00
Longfin		0	0	0.00
Pentamera		0	0	0.00
Rainbow		0	0	0.00
Wrymouths		0	0	0.00
		0	0	0.00
Snailfish		0	0	0.00
Alaska plaice		0	0	0.00
Clams		0	0	0.00
Snails		0	0	0.00
Skate		0	0	0.00
Capelin		0	0	0.00
D. crab		0	0	0.00
Searcher		0	0	0.00
Pricklebacks		0	0	0.00
		0	0	0.00
K. crab		0	0	0.00
Parastichopous		0	0	0.00
Other" crab		0	0	0.00
Octopus		0	0	0.00
Sandfish		0	0	0.00
Herring		0	0	0.00
Butter sole		0	0	0.00
Jellyfish		0	0	0.00
Debris		92.2	9.22	
Total		4699.24		100

Appendix I. Fish and non–shrimp species composition for the near west stratum's cummulative stations catch, spring 1993 survey.

No. of stations	9	total	Avg.	Percent
Pollock		1760.9	195.66	32.51
Flathead		1379.9	153.32	25.48
Arrowtooth		677	75.22	12.50
P.cod		323	35.89	5.96
Sculpins		256.5	28.50	4.74
Skate		250	27.78	4.62
Dover sole		203.9	22.66	3.77
Rockfish, Dusky		172.91	19.21	3.19
Sea anemones		113.9	12.66	2.10
D.crab		40.6	4.51	0.75
T.crab		40.4	4.49	0.75
Wrymouths		30.7	3.41	0.57
Starry flounder		29.9	3.32	0.55
Rex sole		28.7	3.19	0.53
Rockfish, Rougheye		23.16	2.57	0.43
Blackcod		16.2	1.80	0.30
Halibut		15	1.67	0.28
Pricklebacks		12.7	1.41	0.23
Eulochon		10.5	1.17	0.19
Eelpouts		8.7	0.97	0.16
Searcher		8.5	0.94	0.16
Pink scallops		5.3	0.59	0.10
Yellowfin sole		3.4	0.38	0.06
Rockfish,		3.1	0.34	0.06
Poacher		0.5	0.06	0.01
Squid		0.3	0.03	0.01
Rainbow		0	0.00	0.00
Alaska plaice		0	0.00	0.00
Smelt		0	0.00	0.00
Rock sole		0	0.00	0.00
Longfin		0	0.00	0.00
Pentamera		0	0.00	0.00
Snails		0	0.00	0.00
		0	0.00	0.00
Snailfish		0	0.00	0.00
Prowfish		0	0.00	0.00
Clams		0	0.00	0.00
Cucumaria		0	0.00	0.00
Herring		0	0.00	0.00
Parastichopous		0	0.00	0.00
W.vane scallops		0	0.00	0.00
Urchins		0	0.00	0.00
K.crab		0	0.00	0.00
Tomcod		0	0.00	0.00
Capelin		0	0.00	0.00
English sole		0	0.00	0.00
		0	0.00	0.00
Butter sole		0	0.00	0.00
Octopus		0	0.00	0.00
Starfish		0	0.00	0.00
Sandfish		0	0.00	0.00
Jellyfish		0	0.00	0.00
Other* crab		0	0.00	0.00
Debris		111.9	12.43	
		5415.67		100

Appendix J. Fish and non–shrimp species composition for the east open stratum's cummulative stations catch, spring 1993 survey.

number stations	10	total	Avg.	percent
Pollock		1384.4	138.44	26.74
Flathead		1265.1	126.51	24.44
Skate		702.5	70.25	13.57
Halibut		413.8	41.38	7.99
T. crab		359.9	35.99	6.95
Sculpins		304.1	30.41	5.87
P. cod		206.6	20.66	3.99
Arrowtooth		163.3	16.33	3.15
Starfish		74	7.40	1.43
Starry flounder		63.4	6.34	1.22
Tomcod		49.4	4.94	0.95
Yellowfin sole		45.4	4.54	0.88
D. crab		45	4.50	0.87
Dover sole		15	1.50	0.29
Eelpouts		14.6	1.46	0.28
Sea anemones		12.4	1.24	0.24
Snails		10.9	1.09	0.21
Alaska plaice		8	0.80	0.15
K. crab		8	0.80	0.15
Rock sole		6.1	0.61	0.12
W.vane scallops		5.7	0.57	0.11
Eulochon		5.4	0.54	0.10
Blackcod		3.5	0.35	0.07
Pricklebacks		2.3	0.23	0.04
Rex sole		2.2	0.22	0.04
Poacher		1.6	0.16	0.03
Rockfish,	Rougheye	1.6	0.16	0.03
Pink scallops		0.9	0.09	0.02
Searcher		0.8	0.08	0.02
Capelin		0.7	0.07	0.01
Butter sole		0.3	0.03	0.01
Urchins		0.1	0.01	0.00
Herring		0.1	0.01	0.00
Rainbow		0	0.00	0.00
Prowfish		0	0.00	0.00
Wrymouths		0	0.00	0.00
English sole		0	0.00	0.00
		0	0.00	0.00
Snailfish		0	0.00	0.00
Parastichopous		0	0.00	0.00
Clams		0	0.00	0.00
Longfin		0	0.00	0.00
Rockfish,	Dusky	0	0.00	0.00
Sandfish		0	0.00	0.00
		0	0.00	0.00
Octopus		0	0.00	0.00
Squid		0	0.00	0.00
Smelt		0	0.00	0.00
Jellyfish		0	0.00	0.00
Cucumaria		0	0.00	0.00
Other" crab		0	0.00	0.00
Pentamera		0	0.00	0.00
Rockfish,		0	0.00	0.00
Debris				
		5177.1		100

Appendix K. Fish and non–shrimp species composition for the east closed stratum's cummulative stations catch, 1993 survey.

No. of stations	6	total	Avg.	percent
Pollock		894.4	149.07	24.31
Starry flounder		736	122.67	20.00
Flathead		401.2	66.87	10.90
T. crab		363.7	60.62	9.88
Sculpins		341.9	56.98	9.29
Halibut		220	36.67	5.98
Tomcod		212.1	35.35	5.76
P. cod		208.8	34.80	5.67
Yellowfin sole		75.1	12.52	2.04
D. crab		71.7	11.95	1.95
K. crab		41	6.83	1.11
Alaska plaice		17.6	2.93	0.48
Rex sole		15.9	2.65	0.43
Arrowtooth		13.2	2.20	0.36
Blackcod		12.8	2.13	0.35
Capelin		11.2	1.87	0.30
Eulochon		10.2	1.70	0.28
Rock sole		9.1	1.52	0.25
Eelpouts		6.4	1.07	0.17
Poacher		6.3	1.05	0.17
Other" crab		6.1	1.02	0.17
Pink scallops		1.8	0.30	0.05
Herring		1.8	0.30	0.05
Urchins		0.6	0.10	0.02
W.vane scallops		0.4	0.07	0.01
Sandfish		0.3	0.05	0.01
Cucumaria		0	0.00	0.00
Smelt		0	0.00	0.00
Dover sole		0	0.00	0.00
Longfin		0	0.00	0.00
Rainbow		0	0.00	0.00
Clams		0	0.00	0.00
Prowfish		0	0.00	0.00
Jellyfish		0	0.00	0.00
Snails		0	0.00	0.00
Wrymouths		0	0.00	0.00
		0	0.00	0.00
Snailfish		0	0.00	0.00
Pentamera		0	0.00	0.00
Pricklebacks		0	0.00	0.00
English sole		0	0.00	0.00
Butter sole		0	0.00	0.00
Searcher		0	0.00	0.00
Rockfish,	Rougheye	0	0.00	0.00
Rockfish,	Dusky	0	0.00	0.00
		0	0.00	0.00
Parastichopous		0	0.00	0.00
Sea anemones		0	0.00	0.00
Octopus		0	0.00	0.00
Squid		0	0.00	0.00
Starfish		0	0.00	0.00
Skate		0	0.00	0.00
Rockfish,		0	0.00	0.00
Debris		543.7	90.61667	
		3679.6		100

Appendix L. Fish and non–shrimp species composition for the Tutka and Sadie cummulative stations catch, spring 1993 survey.

number stations	2	total	Avg.	percent
Pollock		2317.8	1158.90	67.58
Flat head		402	201.00	11.72
Sculpins		338.3	169.15	9.86
Yellowfin sole		97.4	48.70	2.84
Blackcod		62.1	31.05	1.81
P.cod		46	23.00	1.34
Arrowtooth		40.8	20.40	1.19
T. crab		37.5	18.75	1.09
Rock sole		25.6	12.80	0.75
Tomcod		25.2	12.60	0.73
Herring		22.8	11.40	0.66
Sea anemones		7.7	3.85	0.22
Halibut		3	1.50	0.09
Rockfish,		2	1.00	0.06
Eelpouts		1.3	0.65	0.04
Poacher		0.2	0.10	0.01
Rex sole		0.2	0.10	0.01
Rainbow		0	0.00	0.00
Other" crab		0	0.00	0.00
Parastichopous		0	0.00	0.00
Pentamera		0	0.00	0.00
Cucumaria		0	0.00	0.00
Smelt		0	0.00	0.00
Eulochon		0	0.00	0.00
Jellyfish		0	0.00	0.00
Longfin		0	0.00	0.00
Starfish		0	0.00	0.00
Snails		0	0.00	0.00
Wrymouths		0	0.00	0.00
		0	0.00	0.00
Snailfish		0	0.00	0.00
Prowfish		0	0.00	0.00
Clams		0	0.00	0.00
Starry flounder		0	0.00	0.00
English sole		0	0.00	0.00
Sandfish		0	0.00	0.00
Rockfish,		0	0.00	0.00
Dover sole		0	0.00	0.00
K. crab		0	0.00	0.00
		0	0.00	0.00
Pricklebacks		0	0.00	0.00
Skate		0	0.00	0.00
Butter sole		0	0.00	0.00
Searcher		0	0.00	0.00
D. crab		0	0.00	0.00
Squid		0	0.00	0.00
Alaska plaice		0	0.00	0.00
Capelin		0	0.00	0.00
Pink scallops		0	0.00	0.00
W.vane scallops		0	0.00	0.00
Urchins		0	0.00	0.00
Octopus		0	0.00	0.00
Rockfish,		0	0.00	0.00
Debris		21.2	10.60	0.62
		3429.9		100